Climate Grid Analysis Toolset

Tools for Assessing Regional Climatic Variability

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Abstract

In light of anticipated climate change, increasingly land managers recognize the importance of using historical climatic data to help make informed management decisions.

Gridded climatic datasets, including PRISM and SNODAS, are derived from weather observations, are spatially continuous, and are temporally extensive across the contiguous United States. These represent an excellent source of climatic data which can be used to develop, accurate and park wide, baseline representations of historical climatic conditions.

The Climate Grid Analysis Toolset (CGAT) is a suite of GIS Python scripts developed to facilitate efficient analysis of PRISM and SNODAS datasets. Respectively CGAT performs three analyses for user-defined spatial and temporal ranges (1) cell-based average or totals, (2) percentile calculation, and (3) user-defined zonal statistics.

PRISM and SNODAS Data

PRISM (Parameter-elevation Regressions on Independent Slopes Model) climatic data comes from the PRISM Climate Group at Oregon State University. Using point-based observational data, PRISM data is modeled using the PRISM climate mapping system. PRISM data is spatially continuous for the continental US, and has been modeled from the year 1895 to the present.

SNODAS (SNOw Data Assimilation System) climatic data is modeled by the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center. SNODAS data is available for the continental US at a 1-km spatial resolution with an archive from 2003—the present. See Table 1 for further information on PRISM and SNODAS variables.

Data Summary

Table 1. PRISM and SNODAS variables, output variable unit, CGAT analysis default, and spatial and temporal resolutions.

Data Set	Variable	Variable Unit	CGAT Default	Spatial	Temporal
PRISM	Precipitation	mm	Total	4km	Monthly
PRISM	Average Maximum Temp	Celsius	Average	4km	Monthly
PRISM	Average Minimum Temp	Celsius	Average	4km	Monthly
PRISM	Average Dewpoint Temp	Celsius	Average	4km	Monthly
SNODAS	Snow Water Equivalent	meters	Total	1km	Daily
SNODAS	Snow Depth	meters	Total	1km	Daily
SNODAS	Snow Melt Runoff	meters	Total	1km	Daily
SNODAS	Snowpack Sublimation	meters	Total	1km	Daily
SNODAS	Blowing Snow Sublimation	meters	Total	1km	Daily
SNODAS	Solid Precipitation	kg/sq m	Total	1km	Daily
SNODAS	Liquid Precipitation	kg/sq m	Total	1km	Daily
SNODAS	Snow Pack Average Temp	kelvin	Total	1km	Daily

Working Environment

The CGAT suite is packaged as two sets of python scripts requiring only basic understanding of python/computer programming, and a moderate level of GIS proficiency to use.

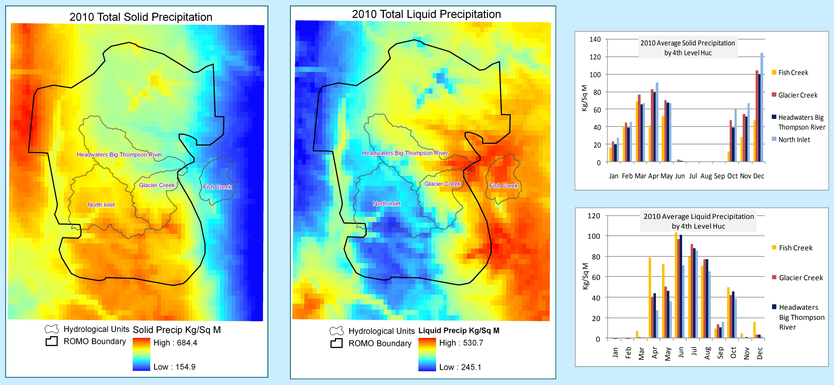
The CGATPython Scripts and SOP can be downloaded from the NPS NR Reference site at http://nrinfo.nps.gov/Reference.mvc/Profile?Code=2166778.

CGAT is the gridded climatic data component of an I&M weather and climatic data project which can be reference at: http://nrinfo.nps.gov/Reference.mvc/

CGAT Analyses

I. Cell Based Average/Total

Cell based averages or totals can be used to develop a baseline value over a temporal range of interest. The cell-based functions calculate the average or total value for each grid cell over the user defined temporal range of interest. Depending on the defined time step, either monthly or yearly cell based calculations will be performed across the defined temporal range.



Maps of the 2010 total solid (left) and liquid (right) precipitation (SNODAS-1025) values for Rocky Mountain National Park. Graphs of 4th level NHD hydrological unit average monthly precipitation (solid & liquid) values by month for 2010.

II. Percentile Calculation

Cell based percentile calculations are derived using the average and total data layers. Percentile calculations are referenced against a year (e.g., 2009) or month within a year (e.g. April 2009). This reference data is then compared against the defined temporal range of interest (e.g. 2000-2009), leading to the calculation of the percentile value. Output from percentile calculation is a percentile grid for the defined reference period.

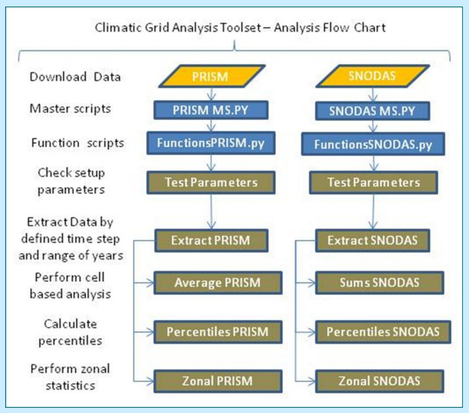
Percentile Formula:

$$Pn = \frac{100}{N}\left(n - \frac{1}{2}\right)$$

N = number of values by cell
n = rank of N percentile data across all N values ordered from least (1) to greatest (N)

III. Zonal Calculation

The third CGAT analysis performs zonal statistics, which calculates summary statistics for specific areas of interest. Example areas could include fire boundaries, watersheds, park boundaries, etc. Output from zonal statistics is a dbf table with the zonal statistics by zone per monthly or annual data layer for PRISM data, or daily data layer for SNODAS data. Statistical zones are defined by the specified field in either a feature class or gird layer zone dataset.

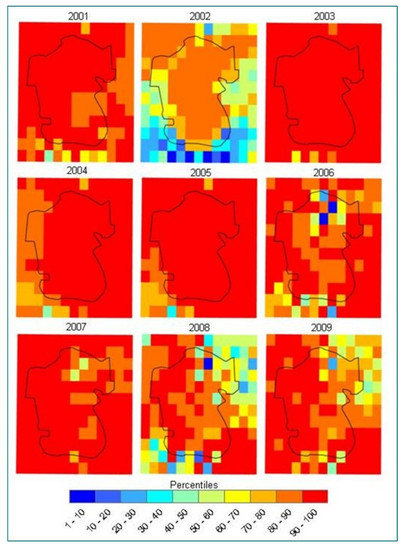


Climate Grid Analysis Toolset - Analysis Flow Chart.

Example Applications

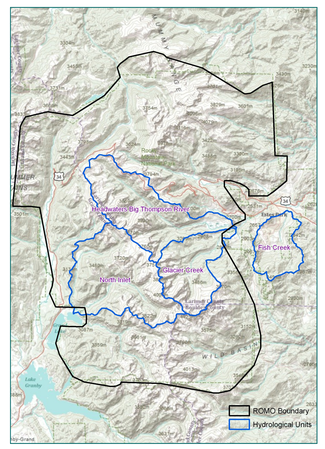
Ashton et. al. (2010) used CGAT and PRISM data to derive 30 year percentile values for the maximum temperature, minimum temperature and precipitation PRISM variables in a regional study of climatic patterns in and around Glacier National Park. This is an excellent example of how CGAT can be used to inform park managers about regional climatological trends.

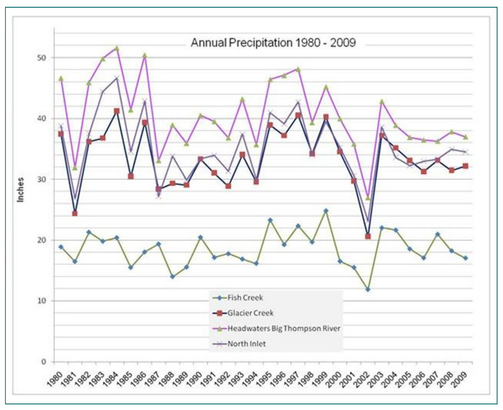
We provide two examples of PRISM output for two PRISM analyses for Rocky Mountain National Park (ROMO). In the first example the annual average minimum temperature (tmin) percentiles for the years 2001-2009 are compared to the tmin values from the previous thirty year period. between 1971-2000.



The PRISM annual mean minimum temperature (tmin) percentile calculations for each year between 2001-2009 versus the thirty year period between 1971-2000 for ROMO (outline in black).

For this nine year period, a majority of the cells have high percentiles in the 80-100 value range, implying the average yearly minimum temperature was substantially higher for the 2001-2009 years relative to the previous thirty years (1971-2000). In this example evidence of higher annual mean minimum temperatures in recent years relative to longer term climatic averages might help park managers better understand complicated processes and drivers (e.g. increased bark beetle outbreaks due to warmer annual minimum temperatures). Upon seeing a strong relationship of increased temperatures, a logical next step might be to evaluate the PRISM data at a finer monthly scale.





Topographic map of Rocky Mountain National Park and four NHD 12th level hydrological units. Graph of annual water year precipitation between 1980 - 2009 for four 12th level NHD .

In the second example (above), the annual precipitation graph between 1980 - 2009 highlights the inter-annual variability in total precipitation. Additionally the graph emphasizes difference in annual precipitation by hydrological units/ zones which likely result from the varying biosphyscial environments(i.e. elevation, topographic positions, windward/leeward, etc.) per zone.

Works Cited

Ashton, I. W., L. O'Gan, and K. Sherrill. 2010. Climate Monitoring in Glacier National Park: Annual Report for 2009. Natural Resource Technical Report NPS/ROMN/NRTR—2010/388. National Park Service, Fort Collins, Colorado.

Sherrill, K.R. and B. Frakes. In Prep. Climate grid analysis toolset – Tools for assessing regional climatological trends. Natural Resource Report NPS/NRPC/IMD/NRR—2011/In Prep. National Park Service, Fort Collins, Colorado.